

Subject-Coded Versus Investigator-Coded Diet Analysis Among  
Overweight Individuals: A Comparison of Methods

by

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## ABSTRACT

The evaluation of nutritional status by dietary intake assessment is fundamental to nutrition research. Accurate assessment allows for health professional-moderated diet adjustment in order to promote disease prevention and management. However, dietary intake can be extremely challenging to measure properly as reliability and accuracy are essential. As technology use has become more prevalent in recent years, an assortment of online, web-based diet analysis methods have begun to emerge. Are these modern methods as accurate as the traditional methods? The aim of this study was to compare and contrast diet analyses from a feeding trial in which both subject-coded (using the Automated Self Administered 24 hour recall, or the ASA24) and investigator-coded (using the Food Processor diet analysis program) diet records were available. Sixty-four overweight (body mass index  $>27\text{-}40\text{ kg/m}^2$ ) members of a campus community between the ages of 20-45 were recruited for an 8-week parallel arm, randomized controlled trial to evaluate the impact of two different pre-dinner meal snacks on satiety, calories consumed, and contribution to modest weight loss. As part of the study requirements, participants completed 3-day food logs at four different times during the trial: pre-trial, and week 1, 4, and 8. Participants also entered their dietary information into the ASA24 website the day after the intake was recorded by hand. Nutrient intake values were compared between the ASA24 records and the handwritten food logs. All statistical analyses were performed using SPSS Statistical Analysis version 19.0; bivariate analyses and Spearman correlation analyses were utilized. Energy, macronutrient, and micronutrient intakes did correlate significantly between the two methodologies, though both under-reporting

and over-reporting were found to exist. Carbohydrate and fiber intakes were under-reported by subjects; retinol, beta-carotene, and vitamin C amounts were over-reported. These results are consistent with previous findings in reporting differences and suggest that the ASA24 is a comparably accurate dietary tracking tool to the traditional diet record method.

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## **Chapter 1: Introduction**

Between 1988-1994 and 2007-2008, the prevalence of obese adults  $\geq 20$  years of age increased from 22% to 34%. In 2007, heart disease topped the charts as the highest leading cause of death; 25% of all deaths were attributed to this chronic condition (National Center for Health Statistics, 2011). Cases of diabetes, hypertension, and other nutrition-related disease states are skyrocketing in this country and around the world. With the increase in obesity and chronic disease prevalence comes an inherent need to study, explore, and understand the long-term impact of nutrition on health.

Evaluation of nutritional status can be conducted in several ways including in-depth physical examinations, laboratory techniques utilizing nutrient blood levels, and assessment of one's diet by various methods (Burke, 1947). This paper will focus on the latter method of nutritional status evaluation, dietary intake assessment. The proper assessment of dietary intake is fundamental in nutrition research. Accurate assessment allows for health professional-moderated diet and exercise adjustment in order to promote disease prevention and management.

Dietary assessment is a complex variable and extremely difficult to measure properly. Reliability and accuracy are of the utmost importance (Huenemann & Turner, 1942). Measuring dietary intake is challenging for many reasons, which include the complexity of food consumption patterns, adherence to tracking, the subjectivity of tracking foods consumed, and various biases associated with intake (Penn et al., 2010).



The most commonly used traditional options for the assessment of food intake include the following: the 24-hour dietary recall (24HDR), the food record, the food frequency questionnaire (FFQ), or a combination of these methods. All three types of assessment have been validated through multiple research studies, and are widely used throughout the world. Each of these methods has distinctive advantages and disadvantages when used alone; however, a combination of methods is often believed to be more effective (Illner, Nothlings, Wagner, Ward, & Boeing, 2010; Penn et al., 2010).

Due to the significant limitations of the traditional assessment methods in collecting accurate and valid information, researchers have taken a closer look at developing new methods of dietary data collection (Penn et al., 2010; F. E. Thompson, Subar, Loria, Reedy, & Baranowski, 2010b). Ideal dietary assessment methods are quick, economical, and user-friendly. However, it is also critical that they provide accurate estimates of food and beverage intakes, with minimal measurement error.

Some of the newer methods include mobile telephone food records, wearable electronic systems, smart cards, PDAs, audio tools such as the Food Recording Electronic Device, digital photography, and web-based tracking of the traditional dietary assessment methods (Chung & Chung, 2010; Ngo et al., 2009; Six et al., 2010; Sun et al., 2010). Advances in technology have opened the door for advantageous modern dietary assessment methods (Arab et al., 2010; F. E. Thompson, Subar, Loria, Reedy, & Baranowski, 2010a). Specifically, an automated version of the 24HDR was created in 1999 that largely impacted the ease of

administering dietary recalls; this tool is the US Department of Agriculture Automated Multiple-Pass Method (AMPM).

The National Cancer Institute's Automated Self Administered 24 hour recall (ASA24) followed the USDA's AMPM system and is among the newest methods of assessment available for use (Subar et al., 2010). The ASA24 provides an automated, 24-hour recall that is completed by the participant at his or her convenience, and is subject-coded. This tool permits multiple recall collection in large-scale epidemiologic studies, and thereby enhances researcher's ability to accurately assess diet. As this methodology is so new, research studies have yet to compare the accuracy of the ASA24 and the traditional diet record approach.

As technology is rapidly changing how individuals interact, the days of face-to-face consultations with clients to obtain dietary intake records may soon become obsolete. "Tele-dietetics" has begun to play a larger role than ever, with website versions of nutrition processes now available that were once only interpreted and analyzed by trained professionals (Chung & Chung, 2010). Hence, the question arises: Are web-based, subject-coded diet analyses accurate?

### **Purpose of Research**

The purpose of this research is to compare and contrast diet analyses from an 8-week feeding trial in which both subject-coded (using the ASA24 online program) and investigator-coded (using the Food Processor diet analysis program) diet records are available. Participants completed 3-day food logs at four times during the trial: pre-trial, and week 1, 4, and 8.

## **Primary Hypotheses**

*H 1:* Macronutrient and energy intakes will not differ for diet records that were subject-coded versus investigator coded.

*H 2:* Micronutrient intakes (sodium, iron, calcium, vitamin C and vitamin A) will not differ for diet records that were subject-coded versus investigator coded.

## **Secondary Hypotheses**

*H 3:* Percentage of recording error differences will be inversely related to weight loss

*H 4:* Compliance with ASA24 recording will be directly related to weight loss during the trial and indirectly related to age.

## **Definition of Terms**

- Tele-dietetics – new process which complements telemedicine and e-health, nutrition services performed through a website (Chung & Chung, 2010).
- Body mass index (BMI) - a body measurement calculated as weight in kg divided by height as m<sup>2</sup> (Ford, Li, Zhao, & Tsai, 2011).
- Automated Self Administered 24 hour recall (ASA24) – created by the National Cancer Institute (NCI); an automated, subject-coded recall method (Subar et al., 2010)

## **Delimitations**

The participants of this study were pulled from the same general demographic. They were sedentary, overweight members of a university community in the southwest United States, Arizona State University, who volunteered for an 8-week feeding trial. Therefore, the results cannot be generalized to the general public.

## **Limitations**

Every dietary tracking method presents the opportunity for error, whether it is intentional or unintentional, or a mistake of the researcher or of the participant. People are protective of their eating styles; many biases go into tracking food and beverage intake. Participants may purposely underestimate their intake, or change their eating habits to reflect better eating in the 3-day logs.

## **Chapter 2: Literature Review**

In order to accurately assess the validity of the web-based, subject-coded analyses, we must first explore the traditional, widely accepted and utilized assessment methods. Next, we will examine the modern techniques of assessment that are emerging today and the validations they have received. Last, we will investigate the newest assessment method, the ASA24. Advantages and disadvantages for each method will be discussed in detail.

### **Traditional Methods of Diet Assessment**

#### **Diet history.**

Burke and Stuart developed one of the earliest methods of diet analysis in the early 1940s in coordination with their research study at the Center for Research in Child Health and Development, established by the Department of Child Hygiene of the Harvard School of Public Health. The researchers were determined to “find a method by which satisfactory information could be obtained on repeated occasions concerning the diet of a child living under normal circumstances in his own home” (Burke & Stuart, 1938). Balance studies, the most popular method of determining nutrient utilization in the body at that time, were inappropriate for this particular study due to cost, time commitment and length of study time. Therefore, a new type of assessment was born: the diet history.

Burke and Stuart developed a consistent method of collecting dietary information as well as a set of forms (24 hour recall and diet history included) in which the data was recorded. They stressed the importance of utilizing a nutritionist in combination with the physician to accurately collect information, as well as to help

educate the parents and children in the study. Using a specific technique for appraising diet, allowing adequate time to conduct the assessment, and securing the confidence of the parents (dietary information providers) were all important guidelines to follow. The consistency maintained throughout their study protocol contributed to a higher level of reliability than other previously used methods (Burke & Stuart, 1938). However, the lengthy interview and trained nutritionist requirements were and remain to be two significant disadvantages of the diet history method.

### **Balance studies.**

Though not appropriate for the previously discussed Harvard School of Public Health study, balance studies were still determined to be the most accurate method of food intake analysis during the late 1940s. This method was looked upon favorably as it offered an estimate of both food consumption and as well as urinary and fecal output. However, this method proved to be costly, time inefficient and unsuitable for large study groups (Burke, 1947).

### **Food weighing.**

Food weighing was another diet analysis method employed at this time. Food was weighed at each meal, by a researcher in a controlled condition or by the participant at home with the use of a scale. This method proved to have several disadvantages whether utilized in a controlled environment or an uncontrolled one. A few drawbacks included the opportunity for biases, the manifestation of artificial circumstances not comparable to real-life, and issues with adherence.

## **24HDR.**

The 24HDR is used as a short-term approach of collecting food and beverage intake amount for the previous day. It has traditionally been used in cross-sectional studies to assess food consumption (Serra-Majem et al., 2009). There are several advantages to this method of assessment. First, it is completed shortly after food consumption has occurred, which decreases the risk of diet behavior alteration by the subject as well as memory recall issues (F. E. Thompson & Subar, 2001). Next, the burden on the participant is minimal due to the short window of recall requirement. Therefore, this method is appropriate for a wide range of populations. Last, extremely detailed food and beverage records can be collected at the time of interview/recording, and later coded appropriately by the interviewer. These detailed records contribute to accuracy.

While the 24HDR collects detailed information, it also requires competent interviewers and significant administration to properly code the data that is recorded. These requirements can lead to high costs in large-scale study use (Illner et al., 2010). The 24HDR may not truly represent the subject's dietary intake; diets vary greatly from day to day (Balogh, Kahn, & Medalie, 1971). Participant attention to detail and adherence also factor into the accuracy of a 24HDR. Are they correctly recording food and beverage types and amounts consumed (F. E. Thompson, Subar, Loria, Reedy, & Baranowski et al., 2010b)?

## **Food record.**

The food record, another approach to collection, is a detailed account of all foods and beverages consumed over a specific period of time (3-7 days). The food

record provides a more reflective portrayal of an individual's intake compared to a shorter record such as the 24HDR. The record is long enough to get a representative sample of foods consumed, but not excessively burdensome to the participant, hindering adherence. Due to the longer length of the required recall, this method can be teamed with weighing or measuring of food items to provide more accurate results (Block, 1982).

This method relies heavily on the participant's ability to accurately track their intake, factoring in memory reliance over a period of time (Illner et al., 2010; F. E. Thompson, Subar, Loria, Reedy, & Baranowski, 2010a). Diet records are often susceptible to social desirability bias, when usual diet habits are changed in response to diet recording. A last disadvantage of this type of analysis is that it requires more of an effort than the shorter methods, and recruited sample size may be smaller (Block, 1982).

### **FFQ.**

A last approach to dietary assessment is the FFQ, in which participants are asked to record commonly consumed foods from a list of foods over a certain period of time. This is the traditional method used in large-scale epidemiological studies due to affordability and self-administration by participants (Serra-Majem et al., 2009; Vereecken, Covents, & Maes, 2010; W. Willett, 1987). FFQ can capture specific dietary changes over time, which is particularly beneficial within certain disease state populations ((F. E. Thompson & Subar, 2001).

FFQ designs vary widely and assume diet regularity among participants, which produces subjectivity and inevitable error in the analysis results. As with all



other self-report assessment methods, FFQ pose the potential risk of inaccurate reporting, bias, data collection and processing errors (Penn et al., 2010; Subar, 2004). Social desirability bias is again a factor, as well as body mass index (BMI) bias. In BMI bias, under-reporting is related to obesity. Both bias types negatively impact research validity (Burrows, Martin, & Collins, 2010).

### **Automation of the 24HDR.**

The US Department of Agriculture Automated Multiple-Pass Method (AMPM) was created in 1999 as a way of collecting 24HDRs in a more effective and efficient manner. The AMPM is a form of dietary data collection that incorporates multiple passes through the 24-hours of the previous day, prompting the participant with cues surrounding types and amounts of consumed foods (Raper, Perloff, Ingwersen, Steinfeldt, & Anand, 2004). Though this method was originally pen and paper, it soon progressed to an automated system.

The subject is interviewed face-to-face by a trained investigator; the investigator concurrently enters the dietary information into the computer. The interview typically lasts 30-45 minutes (Thompson & Subar, 2001). This method provides detailed dietary intake data, and the assurance of a trained individual conducting the recall. However, it is time-consuming and offers the potential for subject and interviewer bias similar to several of the other methods.

### **Validation Studies of Traditional Methods**

#### **24HDR.**

Due to the level of detail and specificity provided in food and beverage intake, the 24HDR has been authenticated in the research time and again as an

effective means of assessing dietary intake. Bingham et al. (1994) compared several methods of analysis including 24HDR, FFQ, weighted records, and estimated diet-records. The results of this exploration confirmed the 24HDR to be the closest in accuracy to the weighted records. FFQs promoted overestimation of certain nutrient groups, particularly fruits and vegetables. The 7-day estimated records were found to be a disadvantage due to the time required to code the data post-record.

Johansson (2008) conducted another validation study of the 24HDR in which four 4-day weighed records were compared to FFQ, repeated 24-hour recalls, 7-day food record, and a 7-day checklist. This experiment included elderly male subjects in the UK. Though 4-day weighed records had proven their accuracy in past research studies, the method was cumbersome and time-consuming for participants to complete. The results of the study demonstrated that the simple 24-hour recall method performed as well as the more complicated methods, including the weighed records. Underreporting was also found to exist within the findings of this study.

### **FFQ.**

Willett et al. (1985) evaluated the reproducibility and validity of a 61-item semi-quantitative FFQ utilized in a large-scale prospective women's study. As discussed earlier, there is a great deal of variation in FFQ structure and content. This particular questionnaire was designed to measure relationships between certain disease states and nutrient consumption. The study included 173 participants; these women were given the questionnaire twice over the course of a year. They also completed four one-week diet records during this time period. Diet records were

selected as the comparison method as they do not rely on memory, and also for their perceived accuracy and feasibility (W. C. Willett et al., 1985).

After comparing the two methodologies, the researchers found that the FFQ did indeed correlate with the diet records on all nutrients but sucrose and total carbohydrate. Those subjects who were categorized in the lowest quintile for calorie intake in the FFQ also fell in the lowest quintile when examining the diet record results. The same was true for the opposite. The women who placed in the highest quintile for caloric intake for the FFQ, were also in the highest quintile for the diet record. The researchers concluded that the inexpensive dietary questionnaire did provide useful nutrient intake information.

Conversely, a study by Serra-Majem et al. (2009) disproved the quality of the FFQ in measuring dietary intake of nutrients. In this particular study, <50% of FFQ validation studies could even be categorized as ‘good’ or ‘very good’; 17% were actually categorized as ‘poor’. Dietary recalls were found to have higher quality scores than FFQ.

### **AMPM.**

In 2002, AMPM became the method employed to collect dietary recalls in What We Eat in America, the dietary assessment portion of the National Health and Nutrition Examination Survey (Agricultural Research Service, n.d.). Moshfegh et al. (2008) were the first to test the validity of this approach by using the doubly labeled water (DLW) technique to compare reported energy intake (EI) with total energy expenditure (TEE). DLW is the gold standard reference for measurements of energy intake validation (Burrows et al., 2010).

The subjects included 524 normal weight, overweight, and obese volunteers aged 30-69 from the Washington DC area. During the two-week study, participants were first dosed with DLW, then proceeded to complete three AMPM 24-hour recalls over the course of the study time. The researchers found that 11% of total participants underreported intake when comparing mean EI to mean TEE. However, <3% of the underreporting occurred among normal weight individuals. This finding implies that the majority of error in reporting occurred in the overweight and obese weight groups (Moshfegh et al., 2008).

The multiple-pass method has been validated as an approach in many other studies. Holmes, Dickt, & Nelson (2007) compared a 4-day weighed inventory against the multiple-pass 24-hour recall (MPR), the food checklist, and the semi-weighed method among a population of low-income households in England. Based on study findings factoring in acceptability and effectiveness, the researchers recommended the multiple-pass recall for use in future studies. Some of the pertinent study findings are captured below (table 1).

Table 1 <i>Comparison of Multiple-Pass 24-Hour Recall, Food Checklist, and Semi-Weighed Methods<sup>1</sup></i>	
Method type	Participant feedback
24-hour recall	Most preferred by interviewers More likely to have more food items reported Supplied the most consistent results across age and sex groups
Food checklist	Most preferred by respondents
Semi-weighed	Least preferred by interviewers and respondents
<sup>1</sup> Results obtained from Holmes et al. (2007)	

Another study by Adamson et al. (2009) that examined an elderly population also found the repeated multiple-pass method to be preferable when compared to

the FFQ. MPR data boasted more realistic estimates of energy and nutrient intakes; however, required greater administration time and costs. Conversely, the FFQ was found to overestimate nutrient intake.

### **Hybrid methods.**

Utilization of a combination of methods has been a controversial topic in the literature whether or not it provides a higher level of accuracy in diet analysis.

According to some researchers, using “blended instruments” maximizes the benefits of individual assessment methods and leads to a more comprehensive method of valuation (Fialkowski et al., 2010; Illner et al., 2010; Penn et al., 2010; F. E.

Thompson & Subar, 2001). Elements of the 24HDR and FFQ have been united frequently to assess specific components of diet. F. E. Thompson & Subar (2001) stress the importance of blended instruments in addition to the development of new analytical techniques to in order to better assess diet.

Conversely, researchers such as Johansson feel that the comparison, or combination, of assessment methods is useless as all methods are subject to error (2008). The attempt to validate one method against another is ineffective in this scenario, as none of the methods are perfectly accurate. It should be noted that this study did not include appraisal of the diet history method, which the researcher feels may be the best method.

### **Nutrient-Specific Analysis Methods**

Beaton et al. (1979) note that error “in dietary methodology is any source of variance that serves to reduce the reliability of the individual data and the group mean” (p. 2554). This study examined the effectiveness of The National Heart Lung

Blood Institute (NHLBI) Nutrition Data System as relative to nutrient and gender differences in diet reporting. The researchers discovered several points of interest, including a gender difference in total nutrient intake, a robust day of the week effect, and noticeable variance among nutrients. The first two findings were associated with the significant observation of women consuming higher overall nutrient intake on Sundays over other days of the week. The variances among nutrients mainly lie in consumption of fatty acids and cholesterol.

The same researchers performed a follow up to this original study in which additional nutrients of interest were analyzed from the same intake database (Beaton, Milner, McGuire, Feather, & Little, 1983). Again, it was noted that the female study participants consumed significantly different food items and amounts of food when comparing weekdays and weekend days. When examining specific nutrient intakes, both Vitamin A and caffeine varied greatly among individuals, meaning a higher degree of difficulty in dietary measurement. The study results warranted the investigators to conclude that there is truly no gold standard of dietary data collection (Beaton et al., 1983). They felt that the presence of false negatives and multiple variables involved in individual dietary analysis were too ambiguous to be overcome with one single method, including their examined study method of the 24HDR.

Nelson, Black, Morris, & Cole (1989) examined the number of days required to properly analyze specific nutrient intake and rank individuals among various British age groups. These data comparisons across six different studies reported some interesting findings, which include the following:

- 7 day diet records generally did not provide the level of accuracy traditionally assumed
- For children  $\leq 4$  years, 7 day records were adequately reflective of all nutrients but copper, retinol, carotene, vitamin B-12, vitamin E, and fats
- For adults, 7 day records were satisfactory in ranking subjects according to specific energy, protein, fat, carbohydrate, calcium, magnesium, phosphorus, saturated fatty acids, and total sugar intakes
- 7 day diet records were not appropriate for accurately reflecting the remaining nutrient intakes for adults or many macro/micronutrient intakes for boys and girls 5-17 years old

Nutrients such as iron, zinc, nicotinic acid, and pyridoxine were more accurately reflected over short, unconnected diet records. Adversely, copper, retinol, carotene, Vitamin B-12, polyunsaturated fatty acids, and alcohol intake levels may be best represented using questionnaires or diet history methodology. The between- and within -subject variation among different nutrients can fluctuate greatly (Nelson et al., 1989).

## **Flaws of Traditional Methods**

### **Under-reporting error.**

Dietary assessment methods are prone to under-reporting and to subject bias errors due to the delicate nature of the topic. People can be very private and sensitive about their eating habits, especially in a situation in which these records are being examined by researchers. Determining a method type that minimizes error while maximizing accuracy is essential.

Subar et al. (2003) navigated the issue of dietary misreporting in the Observing Protein and Energy Nutrition (OPEN) Study. Comparing the self-reported 24HDR and FFQ assessment methods to doubly labeled water and urinary nitrogen helped to determine dietary measurement error in this study. Under-reporting discoveries are summarized below (table 2).

Table 2 <i>Under-Reporting Error Comparison: 24-Hour Diet Recall (24HDR) and the Food Frequency Questionnaire (FFQ) <sup>1</sup></i>						
Gender	Under-Reporting Error (Percentage)					
	24HDR			FFQ		
	Energy/Protein	Energy	Protein	Energy/Protein	Energy	Protein
Men	9%	12-14%	11-12%	35%	31-36%	30-34%
Women	7%	16-20%	11-15%	23%	34-38%	27-32%
<sup>1</sup> Results obtained from Subar et al. (2003)						

Results indicated that under-reporting of protein was less prevalent than that of total energy intake. Perhaps subjects felt more comfortable disclosing protein intake than that of carbohydrate, fat, and alcohol. The reporters also found that increased intake led to increased chance of under-reporting. This phenomenon could be due to participant self-consciousness or lack of memory surrounding foods consumed (Subar et al., 2003).

### **Subject uncertainty.**

A study by Huenemann and Turner (1942) incorporated the use of various analysis techniques, including diet histories, diet records, and repeated diet records. This study demonstrated inconsistency and discrepancy between subject assessment methods, believed to be a result of lacking participant sureness in amounts of foods consumed (Huenemann & Turner, 1942; Young et al., 1952). Other significant



findings in this early study included the uncertainty of diet histories as a means of assessment, the subject ease of weighing food rather than measuring, and the importance of repeated dietary investigation to ascertain a true picture of what a person is consuming.

### **Lack of a gold standard.**

Diet assessment techniques differ from other types of nutritional evaluation methods in the lack of a gold standard (W. Willett, 1987). While DLW is viewed as the gold standard for measurements of energy intake validation, it is certainly not appropriate for use in most studies due to high costs and the requirement of specific facilities for data analysis (Burrows et al., 2010). As various methods of dietary intake analysis have emerged over the years, a certain degree of doubt has remained surrounding the degree of validity and reliability they truly provide. Even the most widely used measurement tools are far from perfect; this is represented by all of the associated disadvantages that have been discussed. The accuracy of a diet assessment relies largely on the participant, on his or her ability and intelligence to complete the record properly (Hart & Cox, 1967).

### **Modern Methods of Diet Assessment**

Due to the numerous limitations of traditional methods, innovative, more defined approaches of dietary assessment have been recently developed. Information and communication technologies (ICT) have been an important addition and are now widely utilized for both diet and physical activity assessment (Ngo et al., 2009). There are several advantages to the application of ICT in these situations including: enhanced data quality, uniformity, and comprehensiveness,

increased time efficiency (researchers and subjects), improved compliance, increased analysis capabilities, cost reductions, and decreased researcher/subject bias related to self-monitoring (Arab et al., 2010; Ngo et al., 2009; F. E. Thompson, Subar, Loria, Reedy, & Baranowski et al., 2010b).

Many of the subsequent modern methods incorporate ICT into their framework in an attempt to improve the accuracy of the data collected. Most of the methods discussed in this section are so new that validation studies have not yet been completed. However, the growing popularity of technology-based methods ensures the future examination of their accuracy and validity.

### **Technology-based methods.**

In a review by Shriver, Roman-Shriver, & Long (2010) technology-based methods are categorized into three distinct groups: those using a computer and software, those using a computer and web-based applications, and those using a portable electronic device. Some examples of methods utilizing a computer and software are the previously discussed AMPM as well as the use of photographs to better estimate portion size. These approaches place more responsibility on the subject to correctly record intake, and therefore eliminate much of the time intensive analysis for the researcher.

The second group of methods Shriver et al. (2010) discuss are those using a computer and web-based application. Compared to computer-based applications, web-based programs offer the advantage of accessibility whenever Internet is available. The MyPlate SuperTracker diet assessment instrument, part of the USDA website, is an excellent example of this as it can be accessed and employed by a wide

range of people. Ease in recruitment of subjects, elimination of unnecessary costs, and error reduction are other potential advantages of web-based systems (Arab et al., 2010).

Personal Digital Assistants (PDAs) are a prime example of portable electronic device technology in diet assessment. The theory behind this type of methodology is improved compliance, validity, and under-reporting/error as a result of simplification in the self-recording process. However, studies have not shown to completely eliminate subject or researcher error by use of these newer methods, it is possible that the type of error is only altered (Shriver et al., 2010).

The demographic of potential technology-based method users is extensive. As more individuals gain access to the Internet worldwide, it makes increasingly more sense to offer these diet analysis programs in a web-based application (Schatzkin et al., 2009). From 2000 to 2008, Internet usage grew by nearly 130% in the United States and is only expected to continue (Internet World Stats, n.d.). In addition, certain research populations such as children and young adults may have increased adherence due to the simplified processes and to the familiarity with computers they have already established (Illner et al., 2011; Shriver et al., 2010).

#### **Electronic nutrient database.**

Researchers at the Harvard School of Public Health developed the Quick Input of Food nutrient database in 1980 (Witschi, Kowaloff, Bloom, & Slack, 1981). This electronic storage/retrieval method aimed to correct some of the issues of both traditional dietary assessment methods as well as those of the pioneer electronic programs. The investigators desired to take advantage of the computerized

programs' proven benefits (improved arithmetic speed and accuracy) while tackling the obstacle of time-consuming coding procedures.

The U.S. Department of Agriculture (USDA) was the primary source of data for this software, which totaled approximately 1,200 foods upon completion. Specific values such as kilocalories, protein, carbohydrate, total fat, saturated/monounsaturated/polyunsaturated fatty acids, and cholesterol could be obtained through the program. As items were entered into the database, they would be further categorized into subgroups based on their food category. The Quick Input of Food program had the capability of locating foods in a variety of ways (first few letters of name, full name, item number) as well as performing basic measurement conversions.

The objective of the research study was to compare among various population groups the accuracy of The Quick Input of Food program to other methods of analysis such as exchange lists, earlier electronic programs, and the old-fashioned by hand version. The new program fared well against the other systems. The reported advantages included reduction of arduous manual coding, elimination of arithmetic error, much quicker selection of foods, and immediate feedback (Witschi et al., 1981).

### **Mobile telephone food records.**

Emerging technology has allowed for recent improvement of mobile phones in many areas: camera and video capabilities, improved data storage, and faster processing (Zhu et al., 2010). It seems as though technology has advanced rapidly with the continual appearance of new and improved “smart” phones in the

marketplace. Mobile phones are so common today that utilizing them for diet tracking and assessment makes perfect sense. Dietary information can be collected throughout the day without subjects having to maintain handwritten records, or carry a separate tracking tool. Similar to findings surrounding web-based applications, cell phones are a diet-tracking mechanism that especially appeals to children and adolescents (Six et al., 2010).

Much of the lure in mobile phone recording lies in the subject's ability to quickly learn and use the desired program, which is termed interaction design or evidence-based development (Six et al., 2010). This includes the involvement of users in the design process in order to promote effective, convenient, and enjoyable use. Six et al. used this technique to explore whether training and repeated use improved proficiency/ experience perception in a group of adolescents 11 to 18 years old.

Subjects photographed their meals with mobile phones and the digital image was sent to the server. The server then identified the food items and amounts, and sent the information back to the subject for verification. While there were a few challenges among the study participants in capturing their entire meal in the image, the majority of the adolescents found the software easy to use. With additional training, the subjects had an even higher level of ease in completing the task. This age group is assumed to possess a high level of technology willingness, so this methodology worked especially well among the participants. However, as cell phones become prevalent among other demographics, they have the potential of becoming a viable dietary tracking tool for all age groups.

Kim et al. (2010) also designed and developed a mobile dietary assessment tool. These researchers based their program design on the following factors: simple, quick daily food image gathering, minimum user burden, flexible eating patterns, personal data protection, automatic data processing, and exceptional situations (ability to save or modify meals). In addition, they incorporated 3D images into their program on a trial basis. The mobile assessment tools are still in their infancy, but have tremendous upside.

#### **Wearable electronic systems.**

Due to the potential risk of error in dietary reporting, Sun et al. (2010) prompted a research study to create an objective electronic device with which to track food intake. The device includes a tiny camera, a microphone, among other components and is worn on a neck lanyard. Pertinent visual data captured by the camera is stored on a memory card until the data is transferred to the analysis computer. The researchers describe this process as almost completely “passive” to the subject: intended to simplify participant responsibility as well as reduce the risk of altered dietary behavior. The device is envisioned to later include other measurement capabilities such as physical activity and human behavior.

This method sounds too good to be true: it cuts back on participant time involvement and also reduces risk of subjectivity in dietary recording. However, there are some considerations before implementation of this complex technology-based tool for dietary analysis. Much of the time saved by the subject in recording food intake is additional time dedicated to processing and analysis by the researcher or dietitian. There is also a hefty time- and monetary commitment included in the

initial build, design, and maintenance of the device and its accompanying software (portion size analysis, food identification, determination of nutrients and calories). The wearable electronic device is still in its early stages, but it has the potential to provide more accurate and objective assessments with proper development.

#### **Smart cards.**

A smart card is a meal payment card that is assigned a specific monetary value and can be used at participating restaurants and cafeterias (Ngo et al., 2009). The process is quite simple: an individual purchases a meal, the tray items are electronically recorded upon checkout, and the data is sent to a central computer. The information can also then be linked to a nutrient database for analysis and coding. Smart cards collect food and beverage purchases, as well as time and date information. Validation studies on this method are lacking; further research is needed to prove or disprove accuracy as a valuable diet assessment tool.

#### **PDA's.**

A PDA is a transportable processing device that allows individuals to track, record, and store information for later use. Various PDA-based diet assessment programs have been designed in an attempt to collect dietary information more efficiently and accurately while further reducing error. One such program is the DietMatePro, a combined Web and PDA application. In a study by Beasley, Riley, & Jean-Mary (2005) participants recorded food intake for three days after being trained to use the DietMatePro. At the end of the three days, subjects returned for a 24-hour recall as well as observed recording of a weighed meal. Researchers determined that the PDA application was comparable to 24-hour recall data in this particular

study; there were no major discrepancies between the two methods for energy and macronutrient intake.

A study by Boushey et al. (2009) examined preferences in diet assessment methods among adolescents, as this can be a difficult age group from which to obtain dietary information. Adolescents tend to eat rather erratically, as well as not demonstrating a huge interest in recording food intake. As discussed earlier, this age group often leans toward the use of technology in recording, whether with the use of a cell phone, or even a PDA. The children were presented with six different approaches to dietary information collection including the following: AMPM, food record, camera with notebook, PDA with hierarchical menu, PDA with search menu, and PDA with camera. The researchers found that the subjects strongly preferred the use of technology-based methods and these methods suggested a higher level of accuracy and adherence (Boushey et al., 2009).

PDA-based systems offer both advantages as well as limitations. Some perks of these systems include food entry time/date stamping, customized alerts, nutritional feedback, and the ability to create favorites (Beasley et al., 2005). On the other hand, a major drawback to this method is the amount of responsibility placed on the subject to select correct foods, record those foods, and estimate portion sizes accurately. Increased subject responsibility means increased subject burden.

### **Digital photography.**

Food images are utilized in many ways in the realm of dietary assessment, whether it involves a subject taking a photograph of their meal or a subject selecting an image that best represents the meal they are consuming. As accurate portion size



information is necessary in all forms of dietary assessment, images can help to reduce ambiguity for subjects in this area (Jia et al., 2011; Subar et al., 2010). A study by Chung & Chung (2010) presents the word ‘tele-dietetics’ to describe a modern process “which complements telemedicine and e-health in a holistic healthcare system” (p. 691). More simply stated, tele-dietetics is the ability to assess nutritional status solely based on Internet interaction. It has the capability to enhance data collection efficiency, minimize distance-related barriers, and increase nutrition services accessibility. Image dietary records are an important part of this process.

Chung & Chung (2010) conducted a comparison between two-dimensional (2D) images and three-dimensional (3D) images as related to reliability and accuracy in food intake recording. While the researchers reported previous study validations using 2D images, they felt there were some limitations that could be overcome by use of 3D images. Both image types were rated in certain categories including ingredient identification, identification of cooking method, identification of sauce type, volume estimations, and oil estimations. Study results demonstrated a higher rating of 2D images in oil estimations and volume estimations. 3D images rated higher in identification of sauce type, and 2D/3D rated equally in ingredient identification and identification of cooking methods. Therefore, 2D images were the conclusive recommended image type by the researchers; they proved to be more universal in this study.

#### **Automation of traditional methods.**

As previously discussed, a major advance was the development of software that automated the 24- hour interview questions. Two of the most widely used are

the University of Minnesota's Nutrition Data System for Research (NDSR) and the USDA's AMPM (F. E. Thompson, Subar, Loria, Reedy, & Baranowski, 2010a). An enhanced consistency of interviewing resulted from these systems due to standardized probes (query details of food and portions). They both also support automated coding of the responses, which aids in producing complete responses obtained in a more timely fashion.

### **New Method Validation**

Vereecken et al. (2010) assessed a group of Belgian-Flemish preschool children's dietary intake by comparing the use of a traditional FFQ and an online valuation tool, the Young Children's Nutrition Assessment on the Web (YCNA-W). Major findings revealed that the two diet evaluation methodologies were similar in assessment of energy and macronutrient intake. However, other nutrient values (fiber, calcium) reflected some variance between the two techniques.

The automated FFQ has also been validated as an effective diet tracking method (Swierk, Williams, Wilcox, Russell, & Meyer, 2011). Swierk et al. (2011) compared an automated FFQ to a 3-day weighted food record and blood biomarkers using 39 healthy adult subjects. The researchers confirmed that the FFQ was both reproducible and valid in assessing omega-3 and omega-6 polyunsaturated fatty acids (PUFA).

Modern method validation, both in comparison to traditional methods and on its own, is in need of further examination. There are many variables surrounding validation of these techniques, a major consideration being that each nutrient is assessed differently. A method that correctly measures macronutrient intake may not

necessarily be accurate when micronutrient consumption is assessed. Despite all of the previously highlighted benefits of the new diet analysis tools, additional studies must be conducted in order to truly determine their validity, accuracy, and reproducibility.

## **ASA24 PROGRAM**

### **Purpose.**

As computer access has dramatically increased throughout the world, so has the feasibility of Internet use for nutritional assessment. Stumbo et al. (2010) express the need for online, freely or inexpensively accessible, software tools within the research community with the capability of nutrient analysis storage, management, and retrieval. The culmination of this type of request within nutritional assessment is the creation of the ASA24 recall tool by the NCI in 2005. Nutrition research is vitally important to the progression and advancement of the field. Unfortunately, validated resources to successfully accomplish dietary assessment across diverse population groups have not always been accessible or affordable to all. The ASA24 satisfies this demand; it is freely available, extensively tested, and widely recognized.

### **Design.**

Based on the AMPM, adaptations were made to the ASA24 in order for the program to be housed on the Internet. This meal-based tool includes audio assistance, specialized graphics, a helpful tutorial, and animated characters. One of the main initiatives of the program as developed by NCI was to simplify the entire nutritional assessment process, both for research subjects as well as researchers. This desire resulted in the need for an easy-to-navigate, user-friendly program.

### **Resources/requirements.**

Resources utilized in building the subject-coded ASA24 interview database included the AMPM Specifications and Interview Databases, The Food & Nutrient Database for Dietary Studies (FNDDS), food portion photographs, and MyPyramid Equivalents Database (MPED) (Zimmerman et al., 2009). The AMPM Specifications Database was the jumping off point for creation of the ASA24 database; this was the location of food detail probes. The FNDDS is a publicly housed database used to obtain nutrient values and measurements. The food portion photographs were provided by Baylor College of Medicine as a result of the development of the Food Intake Recording Software System (FIRSS). Although actual food photographs were not available for every food item upon time of program launch, that is the eventual goal. Lastly, the MPED was used to match dietary recall data with MyPyramid food groups.

Creating a user-friendly tool, reducing food probes, and directing respondents to select specific food pathways were three of the challenges encountered during the development process. First, the program had to be engaging and simple to use in order for participants to be motivated to complete the interview from start to finish. One of the functions of the program was to allow users to search foods consumed in a variety of ways to better fit different memory strategies of participants (i.e. search for the specific food versus browse through a category list). The reduction of food probes was necessary to streamline the interview process and eliminate the number of probes needed to assign a food code. The last challenge, directing respondents to select specific food pathways, also related to

offering specific food choices rather than general. Each of these challenges was met during the development of the program and allowed a greater degree of timeliness and success rate in completing the interview.

### **Features.**

The interview database categorizes ~7,000 Food List Terms into 24 food groups and 243 food subgroups. There are more than 1,100 food probes and over 2 million food pathways. It also includes ~4,400 (with a goal number of 10,000) pictures of individual foods that are displayed in 8 different portion sizes for users to select from (Zimmerman et al., 2009). The above-listed features are designed to collaboratively accomplish the goal of the ASA24: to provide researchers with the ability to economically and feasibly collect dietary intake information in large-scale studies.

### **Validation Studies**

There have yet to be any validation studies on the ASA24. The current study examines the accuracy of the subject-coded ASA24 in comparison to the traditional investigator-coded 3-day food record. For the ASA24 to be validated as a nutritional assessment method, future research must be conducted utilizing this program in contrast to other tools.

### **Summary**

Many different approaches to nutrition assessment have been discussed. As no gold standard approach has emerged as of yet, the search for the best diet analysis tool continues. The traditional methods of analysis including the 24HDR, the food record, and the FFQ are quickly becoming obsolete as more technology-driven

techniques emerge. These modern approaches boast time and cost efficiency, a higher degree of approachability and accessibility within diverse population groups, and improved subject adherence. The development of simplified, user-friendly, freely available programs such as the ASA24 promote enhanced access to quality dietary assessment tools within the research community and beyond.

### Chapter 3: Materials & Methods

The data used in these analyses were derived from an 8-week feeding trial. In brief, 64 overweight (BMI >27-40 kg/m<sup>2</sup>) members of a campus community between the ages of 20-45 were recruited for an 8-week, parallel arm, randomized controlled trial to evaluate the impact of two different pre-dinner meal snacks on satiety, calories consumed, and contribution to modest weight loss. Flyers and email posts announced the study to a university community, and interested individuals were encouraged to complete a short screening tool online.

Eligible participants were non-smokers who did not exercise vigorously >2 times/week. Exclusion criteria also included a recent history of dieting and/or change in body weight ( $\pm 5$ kg); prescription drug use that impacted eating behavior and body weight, unresolved medical conditions and disease, and/or known peanut or tree nut allergy. Participants could not be college freshman as this age group often gains significant weight. Written informed consent was obtained from all participants, and the Institutional Review Board at Arizona State University approved this study.

Prior to baseline, participants met with investigators to provide written consent, complete medical history, demographic and physical activity questionnaires, and receive instructions for food intake. Total study length was 16 weeks; phase 1 was the intervention (weeks 1-8) and phase 2 was the follow-up (weeks 9-16). Participants were stratified by gender, age, and BMI and randomly assigned to the peanut (PN) or whole grain snack bar (SB) arm of the trial. PN participants consumed a 170-calorie serving of peanuts 1 hour before the dinner meal; SB

participants consumed a 140-calorie control snack bar 1 hour before the dinner meal. All participants recorded a 3-day food log prior to the start of the trial and at trial weeks 1,4, and 8. Participants entered their diet data on the NCI ASA24 website the day after the food was recorded. The handwritten logs were returned to the study investigators within 2-weeks. A trained investigator analyzed the diet data using The Food Processor.

## **Diet Analysis**

### **ASA24.**

The interview covers a full day of food and drink intake from midnight to midnight. The three steps for completing the interview are as follows: add meals/food/drinks, add details, and do a final review of items entered. After selecting a meal and entering some general information about the time and location of the meal, the interviewee then chooses the general food and drink that were consumed during that particular meal.

Once all of the meals, snacks, food, and drink have been entered for the day, the system uses food probes to provide further specification of items consumed. For example, mozzarella cheese is listed as a lunch item: what form of mozzarella, sliced or shredded? Was anything added to the cheese? How much of the cheese was consumed? Another example would be a salmon salad: what type of salmon? How was the salmon prepared, and was fat used? What type of greens were they? Was there dressing on the greens? How about vegetables and fruit? The system also prompts users to insert any commonly omitted items such as beverages, condiments, and desserts.



These probes are asked of all food and drink items, they clarify the information being provided and eliminate doubt in analysis. The last section before final review inquires about supplement intake for the day: what type of supplement? How much? What form? Final review is completed last, this section gives interviewees the opportunity to correct mistakes or modify food, drink, or supplement items within the record. The record for the day is then submitted, and the system provides the completed dietary analysis to the researcher. This website succeeds in being extremely user-friendly. Each screen offers an assistant guide, a help button, and tutorials.

### **The Food Processor.**

Released by ESHA (Elizabeth Stewart Hands & Associates) Research in 1981, this nutrition analysis software has been widely used within the nutrition industry for the past 30 years. The program is updated annually. ESHA boasts the presence of the following qualities in The Food Processor program: accuracy, ease of use, customization, adaptability, convenience, solutions, and service.

The program offers over 35,000 food items from which to select while completing analysis. The Food Processor is also user-friendly, it allows researchers to easily input a participant's food and drink items into a specific day then select a variety of ways to analyze the data (macronutrient intake, micronutrient intake, etc.). Similar to the ASA24, ingredients (foods) are selected first, followed by quantity and measure. The system is especially adept at client customization; it collects personal information for clients then outputs personal recommendations based on this

material. For the current study, a comprehensive list of common food and beverage codes was used to reduce ambiguity in coding and to increase accuracy of analysis results.

### **Statistical Analysis**

All statistical analyses were performed using SPSS Statistical Analysis version 19.0. Data are reported as the mean  $\pm$  SE. Dietary data from the ASA24 outputs and The Food Processor outputs will be compared using bivariate analyses and Spearman correlation analyses. Data will be assessed for normality and transformed if necessary. Differences were considered significant at  $P < 0.05$ .

## Chapter 4: Results

### Descriptive Characteristics

Sixty-four overweight participants were recruited to participate in this 8-week study to evaluate the impact of two different pre-dinner meal snacks on satiety, calories consumed, and contribution to modest weight loss. All participants were recruited from the Arizona State University community. Sixty-four participants enrolled in the study, four of which did not show up for any of the sessions. Another sixteen subjects were lost to follow-up during the first eight weeks of the trial. Forty-four subjects completed the trial through week 8. Of this group, twenty-eight completed both ASA24 and handwritten diet records for corresponding days. The remainder of the participants (n=16) did not have ASA24 and/or handwritten matching diet records for the appropriate days. No significant differences were found between these two groups for gender, age, weight, and BMI. Descriptive characteristics of the 28 vs. 16 participants are displayed below (table 3).

Table 3 <i>Baseline Characteristics of Subjects<sup>1</sup></i>			
	Complete record (n = 28)	Incomplete record (n = 16)	P
Gender (m/f)	3/25	5/11	0.302 <sup>2</sup>
Age (y)	41.1±2.0 <sup>1</sup>	39.4±2.7	0.614
Weight (lbs)	184.0±7.0	196.0±10.7	0.333
BMI (kg/m <sup>2</sup> )	31.3±1.1	32.6±1.8	0.514
<sup>1</sup> Data are mean±SE; n=44 <sup>2</sup> P values obtained from independent samples T-test with the exception of gender, which was computed using Chi Square			

For the complete record group, mean subject age was  $41.1 \pm 2.0$  years. The mean weight was  $184.0 \pm 7.0$  pounds, and the mean BMI was  $31.3 \pm 1.1$  kg/m<sup>2</sup>. This average BMI is classified as obese 1 (BMI 30.0-34.9 kg/m<sup>2</sup>). Again, all of the p values were insignificant which indicates no significant differences between the complete record group and the incomplete record group.

## **ASA24 and Diet Record Correlations**

There were 162 total diet records analyzed using corresponding ASA24 entries and handwritten diet records. Various nutrients were analyzed including energy, carbohydrate (CHO), fat, protein, fiber, sodium (Na), iron (Fe), calcium (Ca), vitamin C, retinol, and beta-carotene. Means ( $\pm$ SE) were determined for each of the nutrients to compare the two types of dietary reporting. A trimmed mean (n=147 records) that excluded records with daily caloric intake <800 calories and >3500 calories was also utilized to control for under and over-reporting (Cahill & El-Sohemy, 2009). A correlation run on both 162 diet records (ASA24 & diet records total number) and 147 diet records (trimmed number) reflected significant p values (<0.001) within all nutrients and a correlation coefficient range from 0.461 (relationship strength: medium) to 0.656 (relationship strength: large) (Pallant, 2007). There was no change when controlling for gender. Null Hypothesis 1 and 2 are accepted (table 4). Means and ranges for all ASA24 and diet records (total and trimmed) can be found in table 5. The mean values for energy, fat, protein, Na, Fe, Ca, and vitamin C were similar when comparing ASA24 to diet record data. These mean values maintained similarity with use of the trimmed numbers. The mean values between the two diet methods varied less than 8% for all nutrients with the exception of CHO, fiber, retinol and beta-carotene; these values varied from 16-117% (Table 6).

Table 4 <i>Nutrient Correlation for all ASA24 &amp; Diet Records (Total &amp; Trimmed)</i>				
Nutrient	Total ASA24 & Diet Record Correlation			
	Total (n=162)		Trimmed (n=147)	
	R	P	R	P
Energy	.571	< .001	.484	< .001
Carbohydrate	.644	< .001	.569	< .001
Fat	.495	< .001	.441	< .001
Protein	.461	< .001	.430	< .001
Fiber	.577	< .001	.524	< .001
Sodium (Na)	.526	< .001	.462	< .001
Iron (Fe)	.556	< .001	.514	< .001
Calcium (Ca)	.537	< .001	.492	< .001
Vitamin C	.656	< .001	.678	< .001
Retinol	.517	< .001	.510	< .001
Beta-Carotene	.609	< .001	.630	< .001
<sup>1</sup> P values determined by Spearman correlation analysis				

Table 5 <i>Means and Ranges for all ASA24 &amp; Diet Records (Total and Trimmed)</i>												
Nutrient	ASA24						Diet Record					
	Total (n=162)			Trimmed (n=147)			Total (n=162)			Trimmed (n=147)		
	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max
Energy	1579±48	291	4817	1547±35	811	2883	1692±54	180	4248	1658±44	831	3462
Carbohydrate	181±6	14	616	178±5	45	391	213±7	18	582	211±6	35	495
Fat	61±2	12	141	60±2	14	130	62±3	7	192	61±2	14	192
Protein	70±2	.0	188	73±2	17	187	71±2	11	183	70±2	18	151
Fiber	16±.6	3	38	16±.6	4	38	19±.7	2	66	18±.7	2	44
Sodium (Na)	2802±97	505	7975	2767±92	733	7975	2889±106	147	8368	2852±91	1136	8247
Iron (Fe)	12±.4	3	36	12±.4	5	36	13±.8	.4	71	13±.9	2	71
Calcium (Ca)	801±35	73	3923	794±35	173	3923	764±33	44	2789	765±33	126	2789
Vitamin C	85±9	.0	1218	79±6	.0	444	73±5	.0	289	71±5	.0	254
Retinol	342±16	.0	1064	344±17	3	1064	165±13	.0	1025	166±14	.0	1025
Beta-Carotene	2772±306	5	27931	2687±322	17	27931	1951±287	.0	26607	1829±305	.0	26607

Diet records were further condensed into participant-specific nutrient averages (n=28) and trimmed averages (n=20) for ASA24 and diet records. All correlations reflected a significant p value (<0.001) with the exception of the trimmed sodium average (p=.076) and the total/trimmed retinol average (p=.151 / p=.533). The correlation coefficients ranged from 0.279 to 0.758 (total group) and 0.279 to 0.792 (trimmed group). The relationships were then controlled for gender, which resulted in insignificance in trimmed protein, sodium, and retinol (p=.061, p=.324, p=.291) (table 6). Means and ranges for complete ASA24 and diet records (table 7) and percentage difference in reporting values are below (table 8).

Table 6 Mean Nutrient Correlation for Complete ASA24 & Diet Records (Total & Trimmed)								
	Mean ASA24 & Diet Record Correlation							
	Total (n=28)		Total (n=25)		Trimmed (n=20)		Trimmed (n=17)	
Nutrient	R	P <sup>1</sup>	R <sup>2</sup>	P <sup>2</sup>	R	P <sup>1</sup>	R <sup>2</sup>	P <sup>2</sup>
Energy	.715	< .001	.838	< .001	.740	< .001	.688	.001
Carbohydrate	.675	< .001	.855	< .001	.606	.005	.614	.005
Fat	.708	< .001	.704	< .001	.619	.004	.642	.003
Protein	.696	< .001	.573	.002	.654	.002	.438	.061
Fiber	.758	< .001	.697	< .001	.777	< .001	.727	< .001
Sodium (Na)	.655	< .001	.537	.004	.406	.076	.239	.324
Iron (Fe)	.524	.004	.510	.007	.539	.014	.749	< .001
Calcium (Ca)	.599	.001	.384	.048	.648	.002	.755	< .001
Vitamin C	.679	< .001	.616	.001	.792	< .001	.823	< .001
Retinol	.279	.151	.478	.012	.148	.533	.255	.291
Beta-Carotene	.683	< .001	.659	< .001	.710	< .001	.692	.001
<sup>1</sup> P values represent Spearman correlation analysis <sup>2</sup> R, P indicates controlled for gender using partial correlation analysis								

Nutrient	ASA24						Diet Record					
	Total (n=28)			Trimmed (n=20)			Total (n=28)			Trimmed (n=20)		
	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max	Mean±SE	Min	Max
Energy	1657±80	1141	3103	1582±62	1163	2292	1729±84	1123	2998	1673±62	1123	2345
Carbohydrate	185±11	100	402	177±7	130	244	220±12	118	421	209±8	118	270
Fat	64±4	36	113	61±4	36	110	64±4	22	102	62±4	22	89
Protein	77±5	22	157	75±6	39	157	71±4	43	132	68±3	43	91
Fiber	16±.8	8	24	16±.9	11	23	18±1	11	30	17±1	11	30
Sodium (Na)	2948±242	675	6637	2903±238	1545	6637	2893±154	1603	5045	2811±141	1916	4453
Iron (Fe)	12±.7	7	23	12±.7	7	19	12±1	6	32	11±.8	6	19
Calcium (Ca)	858±85	224	2470	782±54	406	1334	761±52	309	1540	743±51	309	1315
Vitamin C	92±14	25	317	89±15	25	317	82±10	21	219	84±12	21	219
Retinol	346±26	47	759	332±27	47	555	174±26	9	593	158±28	9	466
Beta-Carotene	3080±420	412	8012	2853±493	412	6908	2669±516	94	9397	2648±636	94	9397

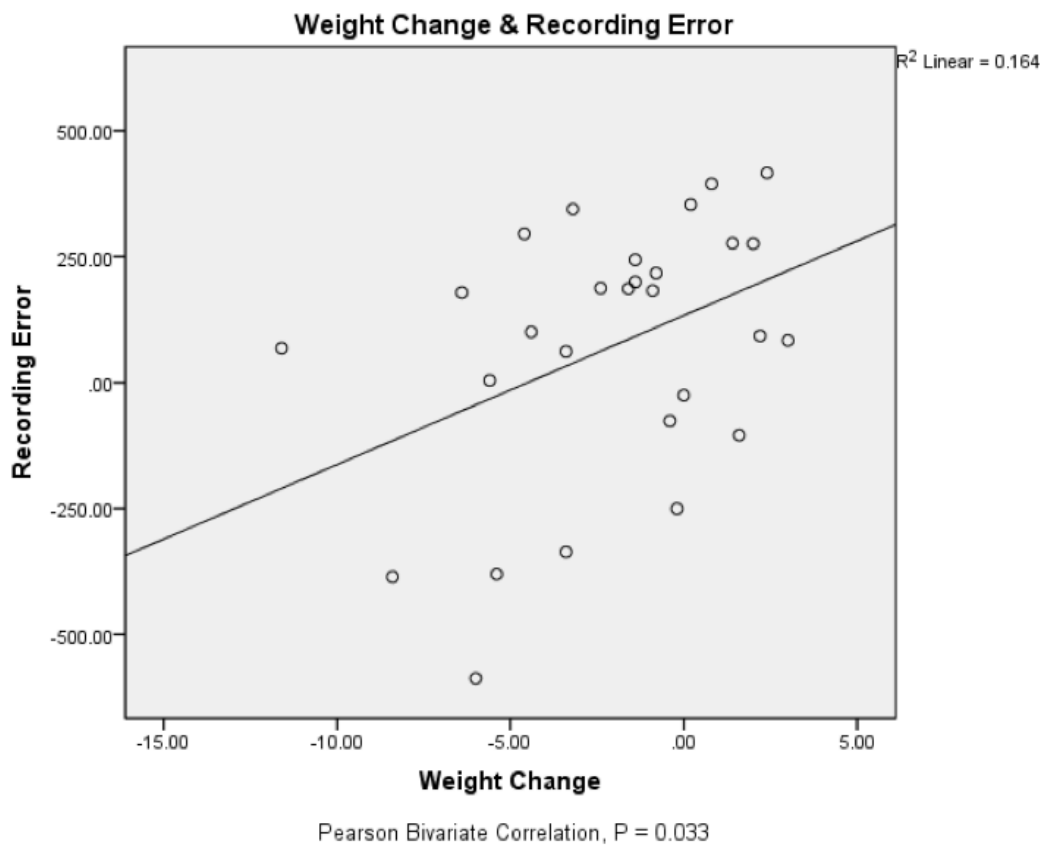
Nutrient	Percent Difference (Untrimmed)	Percent Difference (Trimmed)
Energy	6.7 <sup>2</sup>	6.7
Carbohydrate	15.0	15.6
Fat	1.6	1.6
Protein	1.4	-4.3
Fiber	15.8	11.1
Sodium (Na)	3.0	3.0
Iron (Fe)	7.7	7.7
Calcium (Ca)	-4.8 <sup>1</sup>	-3.8
Vitamin C	-16.4	-11.3
Retinol	-107.3	-107.2
Beta-Carotene	-42.1	-46.9
<sup>1</sup> Negative values indicate subject over-reporting (ASA24)		
<sup>2</sup> Positive values indicate subject under-reporting (ASA24)		



## Weight Change & Recording Error

A correlation was run to determine the relationship between weight change (lbs) and recording error (difference in average energy from ASA24 versus the diet record). The correlation was significant ( $p=0.033$ ), with a correlation coefficient of 0.405. As recording error increased, weight gain increased. Hypothesis 3 accepted (Figure 1).

Figure 1



### Compliance with ASA24 (no use):

#### Related to weight loss.

Only six of the forty-four total participants did not complete any ASA24 diet records. Of this group, an independent samples t-test was used to determine weight loss relative to ASA24 compliance. The mean ( $\pm$ SE) was  $-1.1 \pm 3.8$  (lbs lost) for the ASA24 users and  $-4.7 \pm 2.8$  for the non-ASA24 users. This finding was significant with a p value of 0.039. Compliance did not appear to be directly related to weight loss (table 9).

#### Related to age.

Next, an independent samples t-test was used to determine age relative to ASA24 compliance. The mean ( $\pm$ SE) was  $40.5 \pm 10.9$  (years) for the ASA24 users and  $40.5 \pm 8.6$  for the non-users. This test did not demonstrate any differences in age related to ASA24 use. Hypothesis 4 was rejected (table 9).

Table 9 <i>ASA24 Compliance Related to Age &amp; Weight Loss (No ASA24 Use) <sup>1</sup></i>			
	Yes (n = 28)	No (n = 6)	P
Weight change (lbs)	$-1.1 \pm 3.8$	$-4.7 \pm 2.8$	0.039 <sup>1</sup>
Age (y)	$40.5 \pm 10.9$	$40.5 \pm 8.6$	0.991 <sup>1</sup>
<sup>1</sup> P values obtained from independent samples T-test			

### Compliance with ASA24 (by amount of use):

#### Related to weight loss.

Of the 28 complete ASA24 and diet record subjects, half of the group (n=14) completed ASA24 records <50% of the time ( $\leq 5$  days out of 12 days). The mean ( $\pm$ SE) weight loss for this group was  $-2.0 \pm .85$  (lbs lost). The other half of the group (n=14) completed ASA24 records  $\geq 50\%$  of the time ( $\geq 6$  of the 12 days). The mean ( $\pm$ SE) weight loss for this group was  $-2.2 \pm 1.1$  (lbs lost). Compliance was not significantly related to weight loss ( $p=0.881$ ). Hypothesis 4 was rejected regarding weight change (table 10).

#### Related to age.

The mean ( $\pm$ SE) age for the group that completed ASA24 records <50% of the time was  $45.7 \pm 2.5$  (years old). The mean ( $\pm$ SE) weight loss for the group that completed ASA24 records  $\geq 50\%$  of the time was  $36.4 \pm 2.6$  (years old). Compliance was inversely correlated age ( $p=0.016$ ). Hypothesis 4 was accepted regarding age (table 10).

Table 10 <i>ASA24 Compliance Related to Age &amp; Weight Loss (ASA24 Use)<sup>1</sup></i>			
	$\leq 5$ times (n=14)	$\geq 6$ times (n=14)	P
Weight change (lbs)	$-2.0 \pm .85$	$-2.2 \pm 1.1$	0.881 <sup>1</sup>
Age (y)	$45.7 \pm 2.5$	$36.4 \pm 2.6$	0.016 <sup>1</sup>
<sup>1</sup> P values obtained from independent samples T-test			

## Chapter 5: Discussion

There are various dietary assessment methods available to researchers and nutritionists, ranging from traditional pen-and-paper approaches to modern technology-based techniques. However, all methods run the risk of subject and/or researcher error due to the complex nature of the information being collected. Yet researchers desire an assessment tool that maximizes efficiency. As the traditional methods morph into ones that fit our current technology-filled lifestyles, the ASA24 emerges as an especially attractive option. This correlational study proposed several hypotheses surrounding the ASA24 program and its accuracy related to one of the most widely utilized and validated dietary assessment methods, the investigator-coded 3-day food record. This study found the ASA24 to be largely comparable in accuracy to the 3-day food record.

It was hypothesized that macronutrient and energy intakes would not differ for diet records that were subject-coded versus investigator coded and that micronutrient intakes (sodium, iron, calcium, vitamin C and vitamin A) would not differ for diet records that were subject-coded versus investigator coded. The current study demonstrated that energy, macronutrient, and micronutrient amounts did generally correlate significantly when comparing investigator-coded to subject-coded data. Energy, macronutrient, and micronutrient values were examined both as total diet record nutrient averages and participant-specific nutrient averages. In the total diet record nutrient analysis, the correlation coefficients ranged from medium to large-strength associations. All correlations were significant, even after controlling for gender.

In the participant-specific nutrient average analysis, the correlation coefficient range widened to include low, medium and large-strength associations. The present study reported similar correlation coefficient associations (0.279-0.792) when compared to a previous diet assessment validation study (0.340-0.790) (Willett et al., 1985). All correlations were significant with the exception of sodium and retinol. After controlling for gender, insignificance was determined in protein, sodium, and retinol. Previous studies have demonstrated gender differences in both protein consumption as well as dietary reporting of specific nutrients (Beaton et al., 1979).

The significant correlations between the majority of nutrients indicate an ability of the participants to correctly enter their nutritional data into the ASA24 program based on their handwritten diet records. CHO was the nutrient with the highest under-reported percentage (15.6%). This may have been due to subject under-estimation of CHOs consumed related to inaccurate portion size estimations. Challenges in determining appropriate portion sizes in dietary recall have remained prevalent through the years (Huenemann & Turner, 1942; Young et al., 1952). It could also be hypothesized that subjects were less likely to admit CHO consumption as a result of the association between CHO and weight gain as opposed to protein or fat. Previously conducted studies have had similar findings in the under-reporting of CHO among subjects (Subar et al., 2003; Willett et al., 1985). Fiber was the next highest under-reported nutrient (11.1%), which was a common theme in the study by Vereecken et al. (2010).

There were also a few nutrients that were over-reported in ASA24 analysis

compared to the handwritten records. Retinol (107.2%), beta-carotene (46.9%), and vitamin C (11.3%) were the highest over-reported values. It is possible that the subjects overestimated their fruit and vegetable intake in order to portray healthier eating; this would impact the beta-carotene and vitamin C levels. The study by Beaton et al. (1983) also demonstrated difficulty in vitamin A reporting.

It was hypothesized that percentage of recording error differences will be inversely related to weight loss. The study results indicated a significant correlation between weight change and recording error between the two dietary methods. As participant weight decreased, recording error also decreased. As participant weight increased, so did recording error. This finding suggests that those individuals who were dedicated to the weight loss program entered their diet records more completely and accurately. Therefore, they experienced the benefit of weight loss. The participants who were less motivated to lose weight through the study may have entered incomplete or inaccurate records due to loss of interest.

It was hypothesized that compliance with ASA24 recording will be directly related to weight loss during the trial and indirectly related to age. The first portions of the analysis compared individuals with no ASA24 use to those who used the program. Results indicated that those who used ASA24 actually lost less weight than those who did not. Age related to ASA24 use was not significant either. This hypothesis was rejected; there were no significant correlations found. This group was highly skewed toward the ASA24 use group versus the no use group (n=38, n=6 respectively).

The second half of the analysis looked at two different ASA24 use groups

( $\leq 5$  times and  $\geq 6$  times) relative to weight loss and age. Results indicated that those who used the program over 50% of the time actually lost more weight than their counterparts using the program less than 50% of the time. However, this finding was not significant. When compared to age, compliance was inversely correlated. The group who used ASA24 less than 50% of the time was 9 years older than the group who used ASA24 more than half of the time. This finding could indicate a higher degree of familiarity or comfort with automated, online diet tracking tools for younger subjects (Boushey et al., 2009; Illner et al., 2011; Shriver et al., 2010).

As this is the pioneer study to examine the accuracy of the ASA24 related to a traditional diet assessment method, more research should be conducted in order to validate the ASA24. This study solely compares the ASA24 to the handwritten 3-day diet record. Future research could include more commonly used methods such as the FFQ or the 24HDR.

## **Chapter 6: Conclusion**

Reliable and accurate dietary analysis methods are essential in properly assessing an individual's food and beverage consumption over a specified period of time. In research, accurate dietary assessment can contribute largely to investigation surrounding chronic disease states and BMI/weight status. Traditional methods of dietary assessment have proven to be beneficial throughout the years, but the recent explosion in technology promotes the development and use of modern, technology-based methods. A key player in this game is the ASA24. This web-based automated program collects valuable dietary information in a time and cost-efficient manner while also promoting subject adherence and completion.

This study compared several components of the ASA24 to the traditional 3-day food record: macronutrient and energy intake amounts, micronutrient amounts, percent recording error/weight change, and program use related to age/weight change. The results of this correlational study indicate that the all hypotheses were accepted, with the exception of ASA24 compliance and weight loss. Further studies are required, but the ASA24 appears to be an accurate modern method of tracking dietary intake when compared with the 3-day food record.



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APPENDIX A

INFORMED CONSENT

# **ASU NUTRITION: MEAL PRELOAD TRIAL**

## **INTRODUCTION**

The purposes of this form are (1) to provide you with information that may affect your decision as to whether or not to participate in this research study, and (2) to record your consent if you choose to be involved in this study.

## **RESEARCHERS**

Dr. Carol Johnston, Professor and Director of the ASU Nutrition Program, and Catherine Trier and Katie Fleming, ASU nutrition graduate students, have requested your participation in a research study.

## **STUDY PURPOSE**

The purpose of the research is to examine the effects of meal preloads on satiety and weight loss in overweight individuals.

## **DESCRIPTION OF RESEARCH STUDY**

You have indicated to us that you are healthy and not allergic to nuts or wheat. You have also indicated that you are willing to consume peanuts or whole wheat bars daily for 8 weeks as required in this study; to adhere to the study diet and activity recommendations; to record satiety on 9 occasions; and to use an online system to enter nine 24-hr dietary recalls. Initially you will come to the test site to complete a brief health history questionnaire to demonstrate the absence of medical conditions or situations that may impact the study. At this pre-study visit you will be trained on a computer to enter 24-hr diet information. Your weight and height will be measured and we will measure your waist circumference. The scale that determines your body weight will also provide information regarding your body composition by sending a weak electrical current through your body that cannot be felt. This first meeting will take 1 hour. At this visit you will be scheduled for seven (7) more appointments at the test site which will take about 30 minutes each. At these visits we will repeat measurements of your weight, waist circumference, and body composition. On three of these visits (study weeks 0, 8 and 16) we will ask you to fast overnight for a minimum of 8 hours (no food or drink with the exception of water) and to provide a blood sample. The blood sample is used to assess cholesterol, glucose and insulin concentrations. You will be receiving follow-up phone calls, or emails if preferred, by researchers so any questions can be answered during the study. This study will last 4 months.

At the start of the experiment (study week 0) you will be randomly assigned to the peanut group or to the whole grain bar group; that is, you will not be able to choose which group you are in. You need to eat the specified amount of peanuts (1 oz) or whole grain bar (1 bar) at about 45-60 minutes prior to the evening meal seven days per week. You will be provided an 8-week calendar to keep a record of your consumption of the test foods. All test foods will be provided to you at the start of the study, and at weeks 2, 4, 6, 8, 12, and 16. You will be asked to provide automated 24-hr diet data via emails from the National Cancer Institute. The NCI offers this diet analysis program to researchers across the country. We will register you at the NCI site by subject number only; individuals at NCI will not know your name at any time. You will be asked to complete these diet recalls on nine occasions during the study. During the first 8 weeks of the study, you will be encouraged to follow a diet plan and physical activity program that should promote weight loss. We hope that you will



continue the diet and activity program for an additional 8 weeks on your own, and we will ask you to come back to the test site on two

more occasions for follow-up measurements (weeks 12 and 16). We do not want you to start a different diet or exercise program while you are in the study. If you begin taking new medications during the study, you are to notify the study investigators. About 70 people will participate in this study. This study will take place at the ASU downtown or Polytechnic campus.

### **RISKS**

The experimental food items are commonly consumed foods; yet some participants may be allergic or intolerant to nuts and/or wheat. Individuals will be carefully screened to exclude individuals with these conditions/situations. A trained phlebotomist will perform blood draws under standard and sterile conditions. You may experience temporary pain and bruising of the skin at the site of the needle injection, and feelings of faintness is possible.

### **BENEFITS**

This study will provide information regarding the effect of meal preloads on satiety and weight loss in overweight individuals. We hope that you will lose weight in this study, and you will receive free diet counseling for weight loss. However, it is possible that there will be no direct benefits to you if you participate in this study.

### **NEW INFORMATION**

If the researchers find new information during the study that would reasonably change your decision about participating, then they will provide this information to you.

### **CONFIDENTIALITY**

All information obtained in this study is strictly confidential unless law requires the disclosure. The results of this research study may be used in reports, presentations, and publications, but your name or identity will not be revealed. In order to maintain confidentiality of your records, Dr. Johnston will use subject codes on all data collected, maintain a master list separate and secure from all data collected, and limit access to all confidential information to the study investigators.

### **WITHDRAWAL PRIVILEGE**

You may withdraw from the study at any time for any reason without penalty or prejudice toward you. Your decision to withdraw would not affect you in any manner.

### **COSTS AND PAYMENTS**

You will receive \$225 in gift certificates to Target for full participation in this study. Gift cards will be provided to participants at study weeks 0, 2, 4, 6, 8, 12, and 16.

### **COMPENSATION FOR ILLNESS AND INJURY**

If you agree to participate in the study, then your consent does not waive any of your legal rights. However, in the event of harm, injury, or illness arising from this study, neither Arizona State University nor the researchers are able to give you any money, insurance coverage, free medical care, or any compensation for such injury. Major injury is not likely but if necessary, a call to 911 will be placed.

**VOLUNTARY CONSENT**

Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by Dr. Carol Johnston; 7001 E. Williams Field Rd., Mesa, AZ 85212; 480-727-1713.

If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at 480-965 6788.

This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to you.

Your signature below indicates that you consent to participate in the above study.

\_\_\_\_\_  
Subject's Signature

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
Date

\_\_\_\_\_  
Contact phone number

\_\_\_\_\_  
Email (print clearly)

**INVESTIGATOR'S STATEMENT**

"I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided the subject/participant a copy of this signed consent document."

Signature of Investigator\_\_\_\_\_

Date\_\_\_\_\_

APPENDIX B

IRB APPROVAL

Office of Research Integrity and Assurance

**To:** Carol Johnson  
BDA 331

**From:** *for* Carol Johnston, Chair  
Biosci IRB

**Date:** *01/21* 01/21/2010

**Committee Action:** Expedited Approval

**Approval Date:** 01/21/2010

**Review Type:** Expedited F4 F7

**IRB Protocol #:** 1001004695

**Study Title:** Nut Consumption and Body Weight

**Expiration Date:** 01/20/2011

The above-referenced protocol was approved following expedited review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date. You may not continue any research activity beyond the expiration date without approval by the Institutional Review Board.

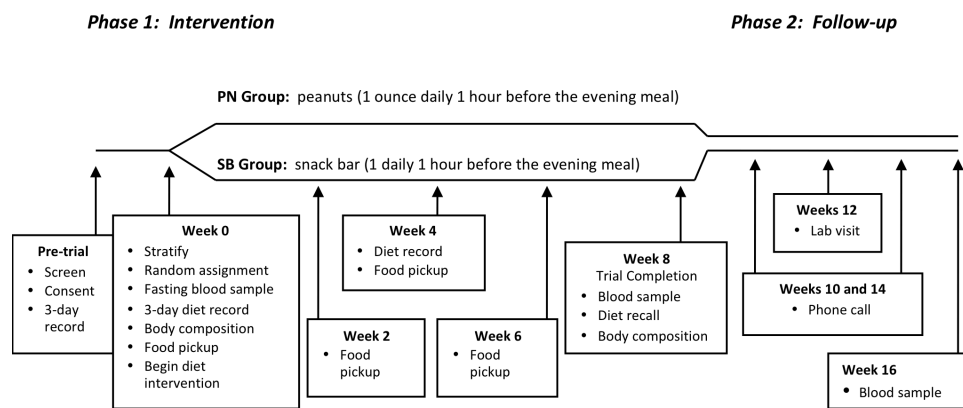
**Adverse Reactions:** If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Biosci IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

**Amendments:** If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Biosci IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

APPENDIX C

STUDY FLOW CHART



**Figure 2.** Peanut trial timeline: Intervention (Phase 1: wk 1-8) and follow-up (Phase 2: wk 9-16)